

CLAIMS

1. A conductive organic-inorganic hybrid material comprising a mineral phase in which walls
5 define pores forming a structured mesoporous network with open porosity; said material further comprising an organic oligomer or polymer integrated in said walls and bonded covalently to the mineral phase, and optionally another phase inside the pores, composed of
10 at least one surface active agent ; at least one of the mineral phase, and the organic oligomer or polymer having conductive and/or hydrophilic functions.

2. The material of the preceding claim, wherein the mineral phase has conductive and/or
15 hydrophilic functions on the surface of its pores.

3. The material of any one of the preceding claims, wherein the organic oligomer or polymer has conductive and/or hydrophilic functions.

4. The material of any one of claims 1 to
20 3, wherein the optional phase composed of at least one surface active agent has conductive and/or hydrophilic functions.

5. The material of any one of claims 1 to 4, wherein said conductive functions are selected from
25 cation exchange groups.

6. The material of claim 5, wherein said cation exchange groups are selected from the following groups: SO_3M ; $-\text{PO}_3\text{M}_2$; $-\text{COOM}$ and $\text{B}(\text{OM})_2$, where M represents hydrogen, a monovalent metal cation, or
30 $^+\text{NR}^1_4$, where each R^1 , independently, represents a hydrogen, an alkyl radical or an aryl radical.

7. The material of any one of claims 1 to 4, wherein said conductive functions are selected from anion exchange groups.

8. The material of claim 7, wherein said anion exchange groups are selected from the following groups: pyridyl, imidazolyl, pyrazolyl; triazolyl; the radicals of formula $^+NR^2_3X^-$, where X represents an anion such as, for example, F, Cl, Br, I, NO_3 , SO_4H or OR, R being an alkyl radical or an aryl radical, and where each R^2 , independently, represents a hydrogen, an alkyl radical or an aryl radical; and the basic aromatic or nonaromatic radicals containing at least one radical selected from imidazole, vinylimidazole, pyrazole, oxazole, carbazole, indole, isoindole, dihydrooxazole, isoxazole, thiazole, benzothiazole, isothiazole, benzimidazole, indazole, 4,5-dihydropyrazole, 1,2,3-oxadiazole, furazan, 1,2,3-thiadiazole, 1,2,4-thiadiazole, 1,2,3-benzotriazole, 1,2,4-triazole, tetrazole, pyrrole, aniline, pyrrolidine, and pyrazole radicals.

9. The material of any one of the preceding claims, wherein the mineral phase is composed of at least one oxide selected from metal oxides, metalloid oxides and mixed oxides thereof.

10. The material of claim 9, wherein said oxide is selected from the oxides of silicon, titanium, zirconium, hafnium, aluminum, tantalum, tin, rare earths such as europium, cerium, lanthanum, and gadolinium, and mixed oxides thereof.

11. The material of any one of the preceding claims, wherein the mesoporous network has an organized structure with a repeating unit.

12. The material of claim 11, wherein the
5 mesoporous network has a cubic, hexagonal, lamellar, vermicular, vesicular or bicontinuous structure.

13. The material of any one of the preceding claims, wherein the size of the pores is from 1 to 100 nm, preferably from 1 to 50 nm.

10 14. The material of any one of the preceding claims, wherein the organic polymer is a thermally stable polymer.

15 15. The material of claim 14, wherein the organic polymer is selected from polyetherketones (PEK, PEEK, PEEKK); polysulfones (PSU); polyethersulfones; polyphenylethersulfones (PPSU); styrene/ethylene (SES), styrene/butadiene (SBS), and styrene/isoprene (SIS) copolymers; polyphenylenes, such as poly(phenylene sulfide)s and poly(phenylene oxide)s; polyimidazoles,
20 such as polybenzimidazoles (PBI); polyimides (PI); polyamideimides (PAI); polyanilines; polypyrroles; polysulfonamides; polypyrazoles, such as polybenzopyrazoles; polyoxazoles, such as polybenzoxazoles; polyethers, such as poly(tetramethylene oxide)s and
25 poly(hexamethylene oxide)s; poly((meth)acrylic acid)s; polyacrylamides; polyvinyls, such as poly(vinyl ester)s, for example, polyvinyl acetates, polyvinyl formates, polyvinyl propionates, polyvinyl laurates, polyvinyl palmitates, polyvinyl stearates, polyvinyl
30 trimethylacetates, polyvinyl chloroacetates, polyvinyl trichloroacetates, polyvinyl trifluoroacetates,

polyvinyl benzoates, polyvinyl pivalates, and polyvinyl alcohols; acetal resins, such as polyvinyl butyrals; polyvinylpyridines; polyvinylpyrrolidones; polyolefins, such as polyethylenes, polypropylenes, and polyisobutylenes; poly(styrene oxide)s; fluoro resins and polyperfluorocarbons, such as polytetrafluoroethylenes (PTFE); poly(vinylidene fluoride)s (PVDF); polychlorotrifluoroethylenes (PCTFE); polyhexafluoropropenes (HFP); perfluoroalkoxides (PFA); polyphosphazenes; silicone elastomers; and block copolymers comprising at least one block composed of a polymer selected from the above polymers.

16. The material of any one of the preceding claims, wherein the surface active agent is selected from: surfactants such as alkyltrimethylammonium salts, alkyl phosphate salts and alkylsulfonate salts; acids such as dibenzoyltartaric acid, maleic acid or long-chain fatty acids; bases such as urea or long-chain amines; phospholipids; doubly hydrophilic copolymers whose amphiphilicity is generated in situ by interaction with a substrate; and amphiphilic multiblock copolymers comprising at least one hydrophobic block in combination with at least one hydrophilic block.

17. A membrane comprising the material of any one of the preceding claims, optionally deposited on a support.

18. An electrode comprising the material of any one of claims 1 to 16.

19. A fuel cell comprising at least one membrane of claim 17 and/or at least one electrode of claim 18.

20. A process for preparing the material of any one of claims 1 to 16, wherein the following steps are realized:

a) - a precursor compound A is synthesized, composed of an organic oligomer or polymer which carries precursor functions of the mesoporous mineral phase, and an organic-inorganic hybrid solution is prepared in a solvent of said precursor compound A;

b) - the organic-inorganic hybrid solution obtained in step a) is hydrolyzed and allowed to age;

c) - the hydrolyzed and aged organic-inorganic hybrid solution of the precursor compound A, obtained in step b), is diluted in a solvent of a mineral precursor B intended to constitute the mesoporous mineral phase, whereby a new organic-inorganic hybrid solution is obtained ;

d) - the organic-inorganic hybrid solution obtained in step c) is hydrolyzed and allowed to age;

e) - a solution is prepared, in a solvent, of a surface active agent D, a templating, texturizing, agent for the mesoporous mineral phase;

f) - the solution obtained in step c) is mixed with the solution obtained in step e) to give a solution S;

g) - optionally, the solution S obtained in step f) is hydrolyzed and allowed to age;

h) - the hydrolyzed and aged hybrid solution S is deposited or impregnated on a support;

i) - solvents are evaporated under controlled pressure, temperature, and humidity conditions;

j) - a heat treatment is carried out to consolidate the material;

5 k) - the surface active agent D is optionally removed completely or partially;

l) - the support is separated or removed, optionally.

21. The process of claim 23, wherein
10 additionally a chelating agent E is added to the solution S obtained in step f).

22. The process of either of claims 20 and 21, wherein, during step c), to the solution based on the organomineral precursor A, a compound C is further
15 added which carries, on the one hand, conductive and/or hydrophilic functions and/or precursor functions of conductive and/or hydrophilic functions, and, on the other hand, functions capable of undergoing bonding to the surface of the pores of the mesoporous network.

20 23. The process of any one of claims 20 to 22, wherein the process further comprises a final step of treatment to liberate or generate conductive and/or hydrophilic functions on the surface of the pores of the material.

25 24. The process of any one of claims 20 to 23, wherein the organic-inorganic hybrid solution obtained in step a) is left to age at a temperature of 0 to 300°C, preferably of 20°C to 200°C; at a pressure of 100 Pa to $5 \cdot 10^6$ Pa, preferably of 1000 Pa to
30 $2 \cdot 10^5$ Pa; for a time of a few minutes to a few days, preferably of one hour to one week.

25. The process of any one of claims 20 to 24, wherein the organic-inorganic hybrid solution obtained in step c) is left to age at a temperature of 0°C to 300°C, preferably of 20°C to 200°C; at a pressure of 100 Pa to $5 \cdot 10^6$ Pa, preferably of 1000 Pa to $2 \cdot 10^5$ Pa; for a time of a few minutes to several days, preferably of one hour to one week.

26. The process of any one of claims 20 to 25, wherein the solution S obtained in step f) is left to age at a temperature of 0 °C to 300°C, preferably of 20°C to 200°C; at a pressure of 100 Pa to $5 \cdot 10^6$ Pa, preferably of 1000 Pa to $2 \cdot 10^5$ Pa; for a time of a few minutes to a few days, preferably of one hour to one week.

27. The process of any one of claims 20 to 26, wherein the solvents are evaporated at a temperature of 0 to 300°C, preferably of 10°C to 160°C; at a relative humidity (RH) of 0 to 100%, preferably of 20% to 95%.

28. The process of any one of claims 20 to 27, wherein, in step h), the organic-inorganic hybrid solution is deposited or impregnated on a support by a method selected from the method of deposition by centrifugal coating known as spin coating, the method of deposition by immersion and withdrawal known as dip coating, the method of deposition by laminar coating known as meniscus coating, the method of deposition by spraying known as "spray coating", the method of deposition by casting and the method of deposition by evaporation.